Base Orthoimagery Specification

Developed by USGS for projects funded under the American Recovery and Reinvestment Act of 2009 and modified for the Maine Orthoimagery Program

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The following specifications, guidelines, and requirements are <u>minimum parameters</u>.

I. General

A. **Geographic Extent**: Each high-resolution ***project*** shall cover the assigned area with a minimum 300 (±30) meter buffer on all exterior project edges. Extents shall be computed by projecting the geographic corners and side midpoints to the appropriate projection, then adding the buffer on each side of the resulting minimum bounding rectangle. The orthoimagery shall be divided into smaller areas or tiles. The tile extent and grid shall be approved per project area.

B. **Non-image data:** Orthoimagery tiles shall not contain any non-image data. Non-image data includes photographic frame borders, fiducially marks, artifacts, and titling.

C. **Datums and Coordinates:** All high-resolution orthoimagery shall be projected in the North American Datum of 1983 (NAD83), zone 19. The vertical datum for the supporting elevation data used to create high-resolution digital orthoimagery shall be North American Vertical Datum of 1988 (NAVD88). The project will be controlled using the latest available NGS control adjustment of the project area, unless another adjustment is specifically requested and described by the customer.

D. **Image Mosaicking**: Orthoimagery may be created using multiple digital images to produce the final product. Specular reflections and other artifacts should be minimized, especially in developed areas.

1. **Radiometry Balance.** When a mosaic of two or more images are made, the brightness and color values of the other images will be adjusted to match that of the principal image. The seamlines between the overlapping images will be chosen to minimize tonal variations. Localized adjustment of the brightness and color values will be done to reduce radiometric differences between join areas. Changes in color balance across the project, if they exist, shall be gradual. Abrupt tonal variations between tiles are not acceptable.

2. **Edge-Matching.** Excessive horizontal displacement along seamlines or at tile boundaries is not allowed**.** The maximum allowable mis-join between transportation features or other well defined linear features is ±3 pixels.

II. Sensor & Acquisition: The following specifications are for the collection and provision of the required high-resolution natural-color aerial imagery. All State of Maine collections will be digital images. Other users of this specification may, at their discretion, request either film-based photographs or digital images. If film is selected, requirements in section IIA (below) should be observed.

A. **Film:** If imagery is captured on aerial film, Kodak 2444 Aerocolor III film or equivalent, or AGFA X100 film or equivalent shall be used. Data providers may choose a film that processes to either a negative or positive image.

B. **Special Collection Conditions:**

1. **Acceptable Window**: The acceptable window for the data collection shall be specific to the project areas based on geographic location and project requirements.

2. **Time of Day and Year:** Imagery shall be collected during minimal shadow conditions. Image collection shall occur when the sun angle is greater than 30-degrees**.** In urban areas containing many high-rise structures, the sun angle should be sufficiently high to minimize shadows.

3. **Collection Conditions:** Imagery shall be collected under conditions free from clouds and cloud shadows, smoke, haze, light streaks, snow, foliage, flooding, and excessive soil moisture. Leaf-off imagery is required.

4. **Tiling:**
The Geotiff files shall represent quarter-quad tiling. Ortho tiles will provide complete coverage for the group and project boundaries based on resolution. Tiles split by the group and project boundaries will be completed to their full tile extent for each resolution. The extent of image coverage over the project area shall be sufficient to ensure void areas do not exist in resulting orthophoto tiles. Full image tiles that meet or exceed the 300 meter buffer specified in section I.A., above, are required. Partial tiles are not considered acceptable.

5. **Calibration:** Aerial Sensors/Camera(s) used to collect project imagery shall have current USGS certification, or in the case of digital sensors a current USGS digital aerial sensor type certification**.**

C. **Camera Station Control:**

1. **Airborne GPS:** Camera position (latitude, longitude, and elevation) shall be recorded at the instant of exposure with airborne GPS. Airborne GPS data shall be differentially corrected and organized as individual data sets grouped by corresponding film roll or flight line. Differentially corrected Airborne GPS positional data shall be stored on portable media, in a nonproprietary format acceptable to each organization. The horizontal root-mean-square error (RMSE) of the airborne GPS control data shall not exceed 20cm. The vertical RMSE of the Airborne GPS control shall not exceed 30cm.

2. **Inertial Measurement unit (IMU) Exterior Orientation Data:** The contractor shall record the camera attitude at the instant of exposure. The IMU data shall be adjusted and organized as individual data sets grouped by corresponding film roll. The RMSE of the adjusted IMU data shall not exceed 30 cm.

D. **Supplemental Ground Control**: All aerial Photography should be captured utilizing IMU and ABGPS technology. If the IMU or ABGPS data is absent, or is not the accuracy required to develop the Ortho Imagery (see Section III A – k) , Aerotriangulation data will be developed.

Differentially corrected GPS ground control, or conventionally surveyed first-order ground control, used to supplement the Airborne GPS positional adjustment shall be stored on portable media, in a non-proprietary format mutually agreeable to the State of Maine and the cooperator. The data provider shall publish and submit a Supplemental Ground Control report that contains narrative, computations and field notes/photos for all points used in the supplemental ground control solution.

E. **Photography Supplemental Report:** The report shall show the flight line numbers and exposure station or strip numbers. The USGS Aerial Photography Supplemental Report form shall be used for this purpose.

F. **Titling:** If film is used, each exposure shall be clearly titled along the north edge (if flown north-south) or west edge (if flown east-west) of the photography. Each exposure shall be marked clearly with a numerical abbreviation of the month, day and year of exposure, the number of the roll, the number of the exposure on the roll, the photo scale expressed as a ratio, and the three letter designator. Coarse Airborne GPS position shall be included in the title as encoded in the camera data chamber. For cameras that do not have camera station positional encoders, the data provider shall manually add the coarse camera position on the opposite edge of the film from the roll exposure designator.

G. **Resolution and Accuracy:** The natural color source imagery shall be of sufficient resolution to support production of digital orthorectified images according to the specifications contained in Section III, A through K, below.

III. Digital Orthophoto Production: Shall be produced consistent with the following requirements:

A. **Aerotriangulation data:** If it is necessary to use Aerotriangulation (AT) in any part of the orthorectification process to supplement or replace ABGPS and IMU, the data shall consist of a minimum of refined image coordinates and adjusted ground coordinates. If Aerotriangulation is performed, the data provider shall provide a comprehensive AT report.

B. **Digital Orthorectified Image Datum**: Digital Orthorectified images shall be referenced to North American Datum 1983, Universal Transverse Mercator (UTM) meters. If a subset adjustment of NAD83 is desired, it must be specified.

C. **Digital Orthorectified Image Color:** Images shall be true color, leaf-off conditions.

D. **Spatial Resolution:** The spatial resolution will be 0.61 meters ground sample distance (GSD) for groups 1 – 8 and 1 meter GSD for groups N1 – N3. Orthoimagery produced under this specification shall not be resampled from the original image, original scan or original capture, with resolution greater or less than the following numbers:

Ground Sample Distance (GSD)	Original Image Resolution	
	Maximum	Minimum
0.61 meters	30.5 cm	65 cm
1 meter	50 cm	107 cm

E. **Horizontal Accuracy:** All orthoimagery shall meet National Map Accuracy Standards:

Ground Sample Distance (GSD)	Horizontal Accuracy
0..61 meters 1 meter	4.054 meters 10.3 meters

1. **Product Accuracy Information Reporting.** Product accuracy information shall be reported according to NSSDA guidelines which are available at: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/index.html
2. At a minimum, statements concerning source materials and production processes used must be provided at the project level sufficient to meet the requirement of section III.E of the guidelines.

F. **Digital Orthorectified Image Format:** Images shall be submitted in uncompressed, true color untiled, ArcGIS readable, GeoTIFF file format along with an ESRI TFW file, Version 1.8.2, (http://www.remotesensing.org/geotiff/spec/geotiffhome.html) with no internal tiling or overviews. Data shall not be compressed during any phase of the production process. Presence of compression artifacts will be cause for rejection. GeoTIFF files shall include (as a minimum) the following GeoTIFF tags and keys:

• ModelTiepointTag
• ModelPixelScaleTag
OR
• ModelTransformation Tag

AND
• GTModelTypeGeoKey
• GTRasterTypeGeoKey
• ProjectedCSTypeGeoKey

G. **Digital Orthorectified Image Tile Size:** Orthorectified Geotiff files shall represent quarter-quad tiling. Ortho tiles will provide complete coverage for the group and project boundaries based on resolution. Tiles split by the group and project boundaries will be completed to their full tile extent for each resolution. Tiles shall be accompanied by an index sheet and shape file suitable for loading into ArcGIS. Index sheet shall include tile boundary and filename.

H. **Digital Orthorectified Image Characteristics:** Relative join (misalignment) of transportation features between adjacent image tiles shall not exceed 3 pixels. Orthophotos shall be tonally balanced to produce a uniform contrast and tone across the image tiles of the entire project. Changes in color balance across the project, if they exist, shall be gradual. Abrupt tonal variations between tiles are not acceptable. Building tilt shall be corrected to the extent that transportation features are not obscured. Ground features appearing in the orthophoto imagery, such as building roof tops, water towers, and radio towers, shall not be clipped at seamlines or between individual tiles. Image artifacts introduced during the scanning process (if applicable) and appearing in the

final orthophotos are unacceptable, except for very minimal artifacts falling in noncritical coverage areas, e.g., a small piece of lint appearing in a timbered area.

I. **Radiometric Resolution**

1. Color Imagery. All color imagery shall be an 8-bit RGB image in accordance with Section 6, RGB Full Color Images, of the TIFF Specification, Revision 6 http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf

2. Color Infrared Imagery. All color infrared imagery shall be an 8-bit Near-IR, RG image in accordance with Section 6, RGB Full Color Images, of the TIFF Specification. http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf

J. **File Naming Convention:** The ortho tile file name shall be derived from the southwest corner of each tile and shall be based on the U.S. National Grid. File names will include Grid Zone Designation (GZD), 100,000 meter block designator and X and Y grid coordinates truncated to 100 meters and year flown. Supplemental instructions for naming Digital Orthorectified Image tiles can be accessed at http://www.fgdc.gov/usng.

K. **Elevation data:** Elevation data created for use in the orthorectification process shall be submitted in a common or non-proprietary format, preferably in an industry-standard, GIS-compatible, 32-bit floating point raster format.

IV. Use and Distribution Rights: All imagery and data produced under this agreement shall become the property of the State of Maine. All data and documentation shall be free from restrictions regarding use and distribution. Data and documentation shall be freely distributable by government agencies.

V. Deliverables:

A. Metadata:

Project and tile metadata describing the orthophoto production process shall be submitted. Federal Geographic Data Committee (FGDC) compliant metadata shall be provided in extensible markup language (.xml) format for each orthorectified tile. FGDC compliant metadata for orthoimage tiles shall be delivered on portable media.

B. **Source Imagery:**

1. **Acquisition Products:** The original natural color film or post processed digital camera files acquired for the project shall be retained and stored by the vendor in accordance with manufacturer's recommendations for a period of 5 years. The standard USGS Film Can Label form will be used for film and 2 copies of the digital imagery will be stored on appropriate media.

2. **Calibration Reports:** Camera Calibration Report(s) for Aerial Camera(s), or in the case of digital sensors, a current Product Characterization Report of the instrument used shall be included as a product.

3. **Camera Station Control:**
    i. **Airborne GPS:** Positional data and a statistical summary report shall be submitted on portable media, in a non-proprietary format mutually agreeable to

the Government and the producer. In addition, the producer shall produce a statistical report summarizing the results of the airborne GPS adjustment.

ii. **IMU Data:** If IMU exterior orientation data are part of the Contractors Technical Proposal, the sensor orientation data and a statistical summary report shall be submitted on portable media, in a nonproprietary format mutually agreeable to the Government and the producer. The producer shall also produce a statistical report summarizing the overall accuracy of the adjusted IMU data.

4. **Supplemental Ground Control:** Differentially corrected GPS Ground Control used to supplement the Airborne GPS positional data shall be provided on portable media, in a non-proprietary format mutually agreeable to the Government and the Contractor.

5. **Flight Diagram**: A Flight Diagram that illustrates the project area outline, the location of the flight lines and, if relevant, the approximate location of image centers shall be included as a product. This diagram shall be provided in hardcopy and softcopy in shape file format suitable for loading into ArcGIS.

6. **Photography and Supplemental Report(s):** A Photography Supplemental Report of all the imagery flown shall be produced for the project. The report shall show the flight line numbers and exposure station or strip numbers. The provider shall use the USGS Aerial Photography Supplemental Report form.

C. Digital Orthophoto Production:

1. **Aerotriangulation data:** Aerotriangulation data, if used in the orthorectification process, consisting of a minimum of refined plate coordinates, adjusted ground coordinates, and statistical summary report shall be submitted to the Government in both hardcopy and softcopy format.

2. **Elevation data:** New elevation data created or modified for use in the orthorectification process shall be submitted in a non proprietary format on portable 2 TB (maximum size) fire wire hard drives.

3. **Delivery Medium and Format:** Digital orthorectified images, in GeoTIFF format along with the ESRI TFW file, shall be submitted on portable 2 TB (maximum size) fire wire hard drive. Image tiles shall be accompanied by an index sheet and shape file suitable for loading into ArcGIS.

VI. **Raw Imagery Capture:** Awarded vendor will store and handle two copies of all raw materials in accordance with the manufacturer's recommendations for a period of 5 years.

VII. Quality Assurance:

A. Quality Assurance shall be performed to ensure that all processes and procedures used, and metadata produced by the data provider were adequate to meet all specifications cited.

1. To facilitate quality assurance the vendor shall, at a minimum, provide the following:
    i. Access to 3 images from each group for color approval before proceeding with orthoimagery production.
    ii. Weekly progress reports including any alternations to the proposed schedule.

2. Visual inspection of the data will be performed for the following
    i. Completeness of data to cover the specified geographic extent, with no void areas or corrupt data.
    ii. Tonal balancing problems across groups by year.
    iii. Ground Sample Distance to ensure that it meets the specified pixel resolution.
    iv. Mis-joins between linear features greater than 3 pixels
    v. Cloud cover, smoke/haze, corrupt data, and void areas.
    vi. Extreme tonal or color variation across seamlines.
    vii. Excessive horizontal displacement along seamlines in images (more than ±3 pixels along transportation features, unless project specifications specifically state otherwise).
    viii. Excessive tilt in bridges, buildings, and other raised features.
    ix. Transportation features obstructed by buildings or shadows.
    x. Clipping of features (e.g. radio towers, water tanks, buildings) at tile boundaries.
    xi. Building/structure warp that may indicate bad elevation data.
    xii. Smearing.
    xiii. Evidence of oversaturation or under saturation as a result of image processing or histogram manipulation across groups by year.
    xiv. Evidence of image compression.

3. Horizontal Accuracy Testing
   Testing is performed if suitable test-point control is furnished as part of the data product. Test-point control must be completely independent of control used during data production.

4. Verification of Metadata
   Verify that accompanying metadata is complete as defined by FGDC metadata standards (http://www.fgdc.gov/metadata).